Response of Small Mammals to Forest Clearings Created by Herbicides in the Central Appalachians

William C. McComb

and

Robert L. Rumsey [1]

Department of Forestry,
University of Kentucky, Lexington, Kentucky 40546

ABSTRACT.— Removal trapping was used to determine relative abundance of six small mammals species on uncut, clearcut, and herbicide-treated plots on ridgetop, southfacing and northfacing sites in eastern Kentucky. Four rates of picloram-based herbicides were tested. Twenty-nine microsite characteristics were measured at each trap station to determine variables important to capture of each species. Clearcuts supported 1.5 times as many small mammals as uncut plots. Relative abundance of *Sorex fumeus, Peromyscus leucopus, Ochrotomys nuttalli,* and *Microtus pinetorum* was higher on at least one of the treatments than on untreated plots. *Sorex fumeus* was captured more frequently on northfacing slopes than on ridgetops. Relative abundances of *Blarina brevicauda* and *Tamias striatus* were unaffected by treatment. Proximity to edge was found to be important to capture of *B. brevicauda, T. striatus,* and *P. leucopus.* Changes in structure of overstory and understory, as well as in snag, log, stump and/or rock characteristics, accounted for differential responses of four species to treatments. *Sorex fumeus, B. brevicauda, T. striatus,* and *P. leucopus* were more tolerant of a wide range of available habitats than were *O. nuttalli* or *M. pinetorum.*

INTRODUCTION

Forest disturbance by clearcutting in small blocks is an accepted method of increasing diversity and/or abundance of those wildlife species that benefit from two or more kinds of habitats (Kirkland 1977). Effects of forest cutting on small mammal communities have been investigated by Gentry et al. (1968), and Hahn and Michael (1980). The structure and composition of understory were reported to be important to soricids, sciurids, cricetids, and microtines by Dueser and Shugart (1978) and Geier and Best (1980). Herbicides affect understory composition and structure, and are frequently used in forest management practices (Dewey 1980; Loftis 1978). McCaffery et al. (1974) found picloram herbicide to be useful in maintaining wildlife clearings in Minnesota, and such herbicides are considered more desirable than others for creating forest clearings because of low toxicity to many vertebrate species (McCollister and Leng 1969). We know of no studies that compare wildlife use of picloram-created forest clearings with clearcut or uncut areas.

[1] Present address: Department of Agriculture, McNeese State University, Lake Charles, Louisiana 70601.

Our objectives were to compare the relative abundance of small mammals among herbicide-created forest clearings, clearcuts, and uncut areas on ridgetop, northfacing, and southfacing sites, and to identify the habitat characteristics selected by each species.

STUDY AREA AND METHODS

Snag Ridge Fork watershed, in the University of Kentucky's Robinson Forest, Knott County, Kentucky, contains a second-growth mixed mesophytic forest typical of much of the central Appalachians (Carpenter and Rumsey 1976). Ridges are dominated by shortleaf pine, *Pinus echinata;* pitch pine, *P. rigida;* chestnut oak, *Quercus prinus;* and scarlet oak, *Q. coccinea.* Southfacing slopes are dominated by hickories, *Carya* spp.; white oak, *Q. alba*; black oak, *Q. velutina*; and sourwood, *Oxydendrum arboreum.* Northfacing slopes are dominated by northern red oak, *Q. rubra*; cucumbertree, *Magnolia acuminata*; and yellow-poplar, *Liriodendron tulipifera.*

Eighteen 0.4-ha square plots in the watershed were sampled. Four plots on each of a northfacing slope, southfacing slope, and ridgetop randomly received one of the following hand-broadcast herbicide treatments in May 1976: 23 kg/ha TORDON 10K (T23), 46 kg/ha TORDON 10K (T46), 68 kg/ha TORDON 10K (T68), or 91 kg/ha M-3864 (M91) (mention of trade names is for identification and does not imply endorsement by the Kentucky Agricultural Experiment Station, Lexington, Kentucky). TORDON 10K is a pelletized picloram-based (4-amino-3, 5, 6-trichloropicolinic acid) herbicide, and M-3864 is a 5% picloram pellet. A fifth plot on each aspect was clearcut; felled trees were not removed. A sixth plot on each aspect was established in the untreated forest at least 75 m from any treated plot. Treated plots were 15 to 50 m apart.

Fifteen stations were established 4.3 m apart perpendicular to the contour through the center of each plot. Two Museum Special snap-traps, baited with peanut butter, were set within 2 m of each station for one night each month on each plot, January to June 1980. Treatments on each aspect were sampled simultaneously, and aspects were sampled on consecutive nights. Stations were grouped into upper edge (5), plot center (5), and lower edge (5). Analysis of variance and Duncan's New Multiple Range Test were used to compare mean captures per station of each species among treatments, aspects, and plot edges versus center. The reciprocal of Simpson's Index ($1/\Sigma P_i^2$, where P_i = proportion of captures in the *i*th treatment) was used as an index to each species tolerance (TI) to habitat changes (Geier and Best 1980). The maximum TI for treatments was 6.00, and for aspects was 3.00.

Twenty-one of twenty-nine microsite characteristics, chosen on the basis of previous studies (Dueser and Shugart 1978; Geier and Best

Table 1. Habitat variables used in correlation and regression analyses, small mammal site preference on clearcut, herbicide-treated and uncut plots, January to June 1980, Robinson Forest, Knott County, Kentucky.

Acronym	Description
NTR	Number of trees > 10 cm dbh within 2 m of a station.
DMT	Diameter of nearest tree (cm).
DST	Distance to nearest tree (m).
BA	Basal area of living stems (m^2 /ha).
NSN	Number of snags> 10 cm dbh, > 1.8 m tall, within 2 m of a station.
DMS	Diameter of nearest snag (cm).
DSS	Distance to nearest snag (m).
NSP	Number of stumps > 10 cm in diameter and < 1.8 m tall, within 2 m of a station.
DSP	Distance to nearest stump (m).
NLG	Number of logs > 10 cm diameter, > 1.8 m long, within 2 m of a station.
DML	Maximum diameter of nearest log (cm).
LGL	Length of nearest log (m).
DSL	Distance to nearest log (m).
PCL	Percent of ground covered by logs within 2 m of a station.
DSR	Distance to nearest rock > 5 cm above ground.
PCR	Percent of ground covered by rocks.
CRN	Percent crown cover above 6.1 m at a station.
MID	Percent vegetation cover between 1.8 and 6.1 m at a station.
LFC	Percent of ground covered by fallen leaves.
CV1, CV2	Percent understory cover < 1.8 m tall per $4m^2$ in Jan. and Apr.
DN1, DN2	Number of understory stems per $4m^2$ in Jan. and Apr.
R1, R2	Number of understory taxa per $4m^2$ in Jan. and Apr.
DIV1, DIV2	Understory species diversity per $4m^2$ in Jan. and Apr.
DWT	Distance to water (m).
SLP	Slope (percent).

1980), were quantified at each station, May 1980 (Table 1). Estimates of cover by rocks, logs, leaves, canopy, and midstory followed methods described by James and Shugart (1971). Understory vegetation characteristics (8) were quantified on 4 m^2 circular plots 2 m away from each station along the contour in January and April 1980. A modified Aldous method was used similar to that described by Murphy and Noble (1972). Percent cover and stem density were determined for each plant taxon on each 4 m^2 plot. Total cover, total density, plant species richness, and Shannon-Weaver plant species diversity were calculated for each station during both sampling periods. Habitat characteristics on treatments and aspects are described in detail by McComb and Rumsey (1981). Correlation and stepwise regression were used to identify microsite characteristics important to the capture of each species.

Since stepwise regression selects variables in a progressive series, some characteristics potentially important to small mammal captures may not have been selected if they were highly correlated with a previously selected variable. Correlation used in conjunction with stepwise regression ensured that any highly correlated microsite characteristics important to small mammal capture were not overlooked. A comparison of PRESS (predicted residual sum of squares) statistics was used to objectively select the best model produced by the stepwise procedure. Each model was entered into the General Linear Models (GLM) procedure with the print (P) and confidence limits (CLM) options specified within the Statistical Analysis System (SAS 79) to provide the PRESS statistic (Helwig and Council 1979). The strongest model was assumed to be the one with the lowest PRESS statistic. Microsite characteristics that were distributed linearly with respect to small mammal capture were identified with this method.

RESULTS

Small Mammal Captures

We captured 385 mammals in 3,250 trapnights (Table 2). *Peromyscus leucopus* accounted for 76.4% of the captures, followed by *Blarina brevicauda* (6.8%), *Sorex fumeus* (6.5%), *Microtus pinetorum* (3.9%), *Ochrotomys nuttalli* (3.6%), and *Tamias striatus* (2.9%). Species richness and species diversity were similar among treatments ($\bar{x}$=4.3, 0.467, respectively) and among aspects ($\bar{x}$=3.0, 0.833, respectively) ($P>0.05$). With the exception of T68, more mammals were captured on clearcut and herbicide-treated plots than on control plots ($P<0.05$) (Table 2), and more mammals were captured on northfacing slopes than on southfacing slopes ($P<0.05$) (Table 3).

More *P. leucopus, O. nuttalli,* and *S. fumeus* were captured on clearcuts than on control plots ($P<0.05$) (Table 2). Kirkland (1977) reported an increase in *S. fumeus* abundance, and only a slight increase in *P. leucopus* abundance, after clearcutting at West Virginia sites. We found no differences in relative abundance of *B. brevicauda* or *S. fumeus* between herbicide-treated plots and control plots; however, with the exception of T46, 100% more *P. leucopus* were caught on herbicide-treated plots than on control plots (Table 2). More *M. pinetorum* were caught on M91 plots than on any other except T23 plots ($P<0.05$).

Table 2. Small mammal captures on uncut, clearcut and herbicide-treated plots, January to June 1980, Robinson Forest, Knott County, Kentucky. (TN = trap nights; values with different letters in each row vary significantly ($P<0.05$)).

Species	Control (N=540TN)	Clearcut (N=540TN)	TORDON 23kg/ha (N=540TN)	TORDON 46kg/ha (N=540TN)	TORDON 68kg/ha (N=540TN)	M-3864 91kg/ha (N=540TN)	TOTAL (N=3,250TN)
Peromyscus leucopus	25c	72a	50ab	45bc	49ab	53ab	294
Blarina brevicauda	4a	6a	6a	6a	2a	2a	26
Sorex fumeus	1b	9a	2b	7ab	4ab	2b	25
Microtus pinetorum	1b	0b	3ab	1b	0b	10a	15
Ochrotomys nuttalli	0b	14a	0b	0b	0b	0b	14
Tamias striatus	1a	1a	3a	4a	2a	0a	11
TOTAL	32c	102a	64b	63b	57bc	67b	385

Table 3. Number of small mammals captured, January to June 1980, from plots with south, north and ridgetop exposures in Robinson Forest, Knott County, Kentucky. (TN = trap-nights; values within each row with different letters vary significantly ($P<0.05$); Duncan's New Multiple Range Test).

Species	Ridge (N=1,080 TN)	South (N=1,080 TN)	North (N=1,090 TN)	Total (N=3,240 TN)
Peromyscus leucopus	103a	92a	99a	294
Blarina brevicauda	6a	9a	11a	26
Sorex fumeus	3b	8a	14a	25
Microtus pinetorum	0b	1b	14a	15
Ochrotomys nuttalli	5a	1a	8a	14
Tamias striatus	3a	5a	3a	11
TOTAL	120ab	116b	149a	385

Sorex fumeus was more abundant on north slopes than on ridges, and *M. pinetorum* was more abundant on north slopes than on ridges or south slopes ($P<0.05$) (Table 3).

Blarina brevicauda (TI=5.24) and *P. leucopus* (TI=5.12) were least sensitive to habitat disturbances due to herbicides or cutting. *Sorex fumeus* (TI=4.03) and *T. striatus* (TI=3.90) were moderately tolerant of habitat disturbances due to herbicides or cutting, and *M. pinetorum* (TI=2.03) and *O. nuttalli* (TI=1.00) were the most sensitive to habitat differences. *Peromyscus leucopus* (TI=2.99), *T. striatus* (TI=2.81) and *B. brevicauda* (TI=2.75) were tolerant of different aspects, followed by *S. fumeus* (TI=2.38), *O. nuttalli* (TI=2.18), and *M. pinetorum* (TI=1.14). Geier and Best (1980) reported *T. striatus* tolerant (TI=4.48) and *B. brevicauda* moderately tolerant (TI=2.73) of habitat change in Iowa (TI_{max}=6.00). The relative tolerance of each species depends upon the small mammal community composition and/or geographic location.

Proximity of trapping station to plot edge was important to the capture of *B. brevicauda, T. striatus*, and *P. leucopus* ($P<0.05$). These species benefitted more from edge presence than did *S. fumeus, O. nuttalli,* or *M. pinetorum.*

Habitat Selection

Results of habitat selection analyses are constrained by the number of microsite characteristics quantified and by the range of values for each characteristic. The results are useful for determining which habitat characteristic within these constraints were important to small mammal captures.

As habitat heterogeneity increased, the capture site for each species became less predictable. Models derived from captures from all plots (habitat-wide) had low R^2 values (5.6 to 26.1). These models selected the habitat characteristics that described the plot(s) with the most captures. Models derived from captures on separate treatments or aspects (habitat-specific) had higher R^2 values (25.6 to 62.1) than habitat-wide models. These models selected characteristics useful in predicting capture sites within a treatment or aspect. In the following discussions, standardized partial regression coefficients are indicated parenthetically.

Sorex fumeus. — A habitat-wide model selected number of logs (SPRC = +0.18) and distance to a rock (-0.12) as important to capture of *S. fumeus,* and both characteristics were correlated ($P<0.01$) with capture (r = +0.20 and -0.16, respectively) (Table 4). Captures were predictable on T46 (R^2 = 47.0), clearcuts (R^2 = 25.6), and southfacing slopes (R^2 = 27.2). Log characteristics (number, diameter, and length) were significant ($P<0.05$) in habitat-wide and in habitat-specific correlation and multiple regression analyses. *Sorex fumeus* was most apt to be caught on clearcuts or heavily treated plots on northfacing slopes with sparse understory (> 8 understory species per 4m^2, < 45 understory stems per 4 m^2), within 4.4 m of a rock, and within 1.7 m of an 8 to 14 m long log.

Blarina brevicauda. — A habitat-wide model selected seven characteristics as important to capture of *B. brevicauda* and four of these variables were also correlated ($P<0.05$) with *B. brevicauda* capture: number of logs (SPRC=+0.31), number of trees (SPRC=-0.16), slope (SPRC= +0.21), and basal area (SPRC = -0.09) (R^2 = 26.1). Relatively many logs, high understory density, and high understory cover were important in habitat-specific models. Gottschalk and Shure (1979) reported high leaf decomposition rates and high microarthropod populations on herbicide-treated forest floors, but Getz (1961) suggested that leaf cover is important in maintaining high humidity within soricid tunnels. Logs may provide moisture-maintaining cover for *B. brevicauda* and *S. fumeus* in areas with low leaf cover and high food availability. *Blarina brevicauda* was most likely captured at the edge of a plot on a northfacing slope > 47%, with > 2logs per 4 m^2, and< 1 tree per 4 m^2 (R^2 = 27.5). Geier and Best (1980) also reported low plant species richness as important to *B. brevicauda* abundance.

Tamias striatus. — Capture sites of *T. striatus* were the least predictable (R^2 = 5.1) of those for the mammals captured. *Tamias striatus* was most likely caught on the edge of a plot within 1.4 m of a log in an area with basal area > 21 m^2/ha, < 8 understory species per 4 m^2 , and > 55 understory stems per 4 m^2 . Dueser and Shugart (1978) and Geier and Best (1980) reported high understory density or cover as important

Table 4. Means and standard deviations (in parentheses) of habitat characteristics for six small mammal species, and correlations between habitat characteristics and small mammal captures, Robinson Forest, Knott County, Kentucky, January to June 1980. (A (+) or (-) indicates significant ($P<0.05$) linear correlation; definitions of habitat characteristics given in Table 1; N = number of capture sites).

Habitat characteristic	*Sorex fumeus* (N=24)	*Blarina brevicauda* (N=26)	*Tamias striatus* (N=9)	*Peromyscus leucopus* (N=172)	*Ochrotomys nuttalli* (N=11)	*Microtus pinetorum* (N=8)	Overall (N=270)
NTR	0.3(0.6)	0(0)$^{-}$	0.4(0.7)	0.2(0.5)$^{-}$	0(0)	0.1(0.4)	0.3(0.6)
DMT	24.2(8.1)	29.9(11.9)	21.9(7.2)	28.9(14.5)	36.2(24.4)	23.8(5.4)	28.5(14.5)
DST	9.3(9.3)$^{+}$	7.4(7.1)	3.5(1.9)	7.4(8.2)$^{+}$	22.1(12.0)$^{+}$	3.8(1.7)	6.2(7.5)
BA	15.4(6.9)$^{-}$	15.6(5.4)$^{-}$	21.0(5.7)	17.5(6.7)$^{-}$	6.5(4.9)$^{+}$	23.6(4.5)	18.4(6.9)
NSN	0.3(0.4)	0.2(0.4)	0.1(0.3)	0.2(0.4)	0(0)	0(0)	0.2(0.4)
DMS	23.3(10.4)	23.6(10.8)	25.6(13.0)	28.1(16.8)	16.4(11.7)$^{-}$	27.6(12.6)	26.8(15.7)
DSS	14.0(13.2)	10.9(12.0)	8.6(7.0)	10.8(10.9)$^{+}$	28.3(4.1)$^{+}$	6.6(4.7)	10.2(9.9)
NSP	0.3(0.4)	0.4(0.6)	0.3(0.5)	0.4(0.6)$^{+}$	0.5(0.7)	0.3(0.5)	0.3(0.6)
DSP	5.0(4.1)	5.5(4.5)	5.5(5.3)	5.0(4.3)$^{-}$	3.1(1.9)	5.0(3.0)	5.3(4.5)
NLG	2.6(2.5)$^{+}$	2.4(4.2)$^{+}$	2.1(2.0)	1.8(2.2)$^{+}$	3.8(2.1)$^{+}$	1.0(1.7)	1.5(2.1)
DML	23.3(38.0)	26.6(41.1)	21.7(37.8)	19.7(31.4)$^{+}$	28.6(26.3)	11.5(18.9)	16.5(27.9)
LGL	11.6(7.1)$^{+}$	8.0(6.9)	9.4(6.5)	9.3(6.3)$^{+}$	14.6(4.6)$^{+}$	5.5(4.0)	8.6(7.1)
DSL	1.7(2.7)$^{-}$	2.2(2.8)	1.4(1.9)	2.8(3.5)$^{-}$	1.1(0.8)	2.5(2.8)	3.3(3.8)
PCL	12.5(12.1)$^{+}$	8.3(11.1)	12.2(16.0)	9.0(11.7)	29.5(26.2)$^{+}$	6.3(11.9)	7.7(11.3)
DSR	4.4(6.6)$^{-}$	8.4(9.9)	11.9(12.9)	9.1(10.4)	5.4(6.6)	4.6(3.3)	10.0(11.1)
PCR	6.3(10.1)$^{+}$	4.6(6.0)	3.9(4.9)	3.8(6.8)	5.4(5.2)	2.5(5.3)	3.3(6.2)
CRN	23.5(25.7)	22.0(25.2)	25.0(26.0)	24.8(27.0)$^{-}$	0.5(1.5)$^{-}$	55.0(26.2)	31.6(30.6)

MID	20.0(24.4)	34.4(34.3)	33.3(35.3)	26.4(29.8)	23.6(28.5)$^{-}$	15.0(27.0)	28.0(30.8)
LFC	41.3(28.9)	44.3(30.9)	43.9(34.1)	52.4(32.4)	25.0(22.8)$^{-}$	65.0(25.6)	56.0(32.7)
CV1	62.5(29.3)	63.9(23.0)	70.6(26.3)	71.4(31.2)$^{+}$	89.1(34.7)	76.3(37.3)	67.0(29.5)
CV2	55.2(22.4)	51.6(20.8)	56.1(29.3)	54.9(24.2)	49.5(15.9)	48.8(20.5)	52.3(22.5)
DN1	46.4(29.3)	55.6(43.7)	55.2(40.3)	48.5(33.2)	56.9(22.2)	72.5(88.6)	46.8(35.2)
DN2	41.7(25.5)	37.8(27.9)	48.8(53.7)	37.4(22.6)	29.7(16.5)	38.1(39.6)	36.4(24.1)
R1	8.0(2.4)	7.6(2.5)	7.7(2.4)	7.9(2.3)$^{+}$	9.4(2.2)$^{+}$	8.5(2.0)	7.5(2.4)
R2	8.0(2.2)	6.7(2.6)	6.0(1.3)	7.4(2.4)	6.8(1.7)	7.8(2.4)	7.1(2.4)
DIV1	5.18(0.92)	5.38(1.02)	5.47(0.97)	5.26(0.85)$^{+}$	5.72(0.58)	5.20(1.41)	5.16(0.91)
DIV2	5.07(0.73)	4.80(0.95)	5.09(1.17)	4.94(0.78)	4.71(0.69)	4.68(1.35)	4.88(0.81)
DWT	117.5(75.2)	98.1(66.1)	89.5(38.8)	103.7(65.5)	146.4(15.5)	47.8(87.6)	102.4(65.5)
SLP	38.6(23.5)	46.7(25.0)$^{+}$	38.9(25.5)	36.7(23.6)	21.1(23.5)	50.0(16.3)	36.2(22.5)

to captures of *T. striatus,* but they also found high plant species richness a characteristic important to this species.

Peromyscus leucopus. — The habitat-wide model selected crown cover (-0.28) and log diameter (+0.17) as important to capture of *P. leucopus* ($P<0.05$). Captures were most strongly correlated ($P<0.01$) with crown cover (-0.31), log diameter (+0.23), basal area (-0.22), distance to log (-0.21), log length (+0.20), and distance to a tree (+0.20) (Table 4). Understory structure and log characteristics were correlated ($P<0.05$) with capture on four and three of the treatments, and three and two of the aspects, respectively. The importance of each microsite characteristic to capture of *P. leucopus* varied among treatments and probably varies geographically. Dueser and Shugart (1978) reported a deciduous overstory, wide tree dispersion, high species richness, and large stumps important to *P. leucopus* in Tennessee. Geier and Best (1980) found logs, brushpiles, and low plant species richness important to *P. leucopus* abundance in Iowa. The most likely place to capture *P. leucopus* in our plots was on the edge of a clearcut with an understory of > 8 species and > 50 stems per 4 m^2, and within 2.8 m of a log over 20 cm in diameter, on a site covered more than 4% by rocks (R^2=47.3).

Ochrotomys nuttalli. — This species selected sites on clearcuts with slopes > 21%,< 146 m from water, with < 25% leaf cover, > 50% understory cover, > 1.1 m from a log and > 5.4 m from a rock (R^2=62.1). Dueser and Shugart (1978) and Linzey (1968) identified dense understory cover as important to *O. nuttalli* in Tennessee, but they did not report leaf cover (SPRC = -0.86), logs (SPRC = +0.29), or rocks (SPRC = +0.52) as important to this species.

Microtus pinetorum. — A habitat-wide model selected understory diversity (-0.98), understory density (+0.90), understory richness (+0.76), basal area (+0.81), and tree density (-0.69) as important to capture *M. pinetorum.* Kirkland (1978) also reported microtines responding to changes in vegetative structure at West Virginia sites. *Microtus pinetorum* was most likely captured on the M91 plot on northfacing slopes with a basal area > 24 m^2/ha, near a snag < 28 cm dbh, on a 4 m^2 site with < 1 tree, and with logs < 5.5 m long (R^2=32.6).

DISCUSSION

Differential response of small mammals to treatments and aspects is a function of differences in the relative abundance of individuals, and of habitat components among sites. Results of studies of habitat preferences and relative abundances of small mammals may differ from ours if conducted in a contiguous rather than a discontiguous forest. Four species responded to treatments by change in relative abundance and two species responded to aspects by the same change. Biotic microsite characteristics (vegetative cover, logs, stumps, leaf cover, etc.) were important to capture of all six species, but abiotic factors (rocks, slope, water) were also important to capture of *S. fumeus, B. brevicauda, P. leucopus,* and *O. nuttalli.* Habitat characteristics selected by most species were similar to those reported by previous investigators, but there were a few notable exceptions. The similar relative abundance of *S. fumeus* and *B. brevicauda* on southfacing and northfacing slopes would be unexpected based on the findings of Manville (1949), Pruitt (1953), Wetzel (1958), Getz (1961), and Barbour and Davis (1974) who reported moisture as important to the occurrence of shrews. Contrary to Getz (1961), we did not find leaf cover correlated with soricid capture. Gottschalk and Shure (1979) and Bormann and Likens (1979) reported that herbicides and clearcutting, respectively, will increase leaf litter decomposition rates and increase microarthropod populations; microarthropods are important food items in soricid diets. Log cover was important to capture of both species; logs may serve as moisture-maintaining cover and/or feeding sites for shrews. Several authors have reported *B. brevicauda* to be tolerant of a wide range of habitats (Getz 1961; Briese and Smith 1974; Geier and Best 1980), but no similar estimate of tolerance is available for *S. fumeus.* We found *S. fumeus* not as tolerant of site differences as *B. brevicauda,* but it was relatively tolerant of site change within the small mammal community we sampled. *Sorex fumeus* and *B. brevicauda* were similar in abundance on each aspect and treatment, and both selected similar microhabitats. The number of logs per 4 m^2 was the most useful variable in predicting captures of both species, and log cover was also important to both species. Occurrence of *S. fumeus* was positively associated ($r = +0.31$; SPRC = +0.26) with understory species richness on northfacing slopes, while *B. brevicauda* occurrence was associated negatively (SPRC = -0.12) with understory species richness in the habitat-wide regression model. Geier and Best (1980) also reported low plant species richness as important to occurrence of *B. brevicauda.* Coexistence of these shrews seems to be allowed by subtle differences in vegetative structure. Additional research is needed to determine differences in foods, microhabitats, and microclimates of these two sympatric soricids.

Dueser and Shugart (1978) compared microhabitat characteristics among *P. leucopus, O. nuttalli,* and *T. striatus.* Our results support their findings: *P. leucopus* and *T. striatus* are more tolerant of a wide range of habitat characteristics than are *O. nuttalli.* We found *O. nuttalli* associated ($r>0.40$) with high log cover and canopy openings (+DST, +DSS, and -BA) on ridges and north slopes. *Peromyscus leucopus* was associated to that degree ($r>0.40$) with low crown cover on ridges, but otherwise was not strongly associated with any particular habitat characteristics, and *T. striatus* occurrence was not correlated

($P<0.05$) with any habitat characteristic. Dueser and Shugart (1978) suggested that since *T. striatus* is diurnal and *P. leucopus* is nocturnal, and since they differ morphologically, they can coexist with little competition. *Microtus pinetorum* was found most frequently on M91 on northfacing slopes, and was intolerant of other sites. Understory and overstory structure was important to capture of *M. pinetorum,* and these characteristics differed from characteristics important to the other rodents sampled. Variation in vegetative structure seemed to allow coexistence of *M. pinetorum* with other rodents on northfacing slopes. If competition is occurring within the small mammal community on our study areas, then it is probably most intense on northfacing slopes and least intense on ridgetops.

Differences in relative abundance and habitat selection among different physiographic sites may allow a more complete understanding of small mammal species distribution within a watershed, and may increase our understanding of niche overlap and competitive exclusion among sympatric small mammals.

Management Implications

An increase in small mammal abundance may be desired as a nongame management practice or to produce small mammal biomass for predatory game or furbearers. If nongame management is an objective, then plots should be small and widely spaced to maximize edge. Habitat alterations should include providing habitat for species intolerant of habitat variety, such as *O. nuttalli* (clearcut) and *M. pinetorum* (herbicide, preferably similar to M-3864). Resulting increases in rock exposure and microarthropod populations through increased leaf decomposition on herbicide and clearcut plots (Bormann and Likens 1979; Gottschalk and Shure 1979), and in log abundance, stump abundance, and understory density, will benefit the six species studied.

Small mammals were 1.5 times more abundant on clearcuts than on herbicide plots, and twice as abundant on herbicide-treated plots than on uncut plots. Pelleted herbicide application is less expensive than cutting (Dewey 1980), but the resulting increase in small mammal biomass following herbicide application up to 91 kg/ha is also less than results from cutting. Limited accessibility, ruggedness of the terrain, and/or increasing fuel and labor costs may influence managers to use herbicides to create clearings for wildlife.

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LITERATURE CITED

Barbour, Roger W., and W. H. Davis. 1974. Mammals of Kentucky. Univ. Press Kentucky, Lexington. 322 pp.

Bormann, F. Herbert, and G. E. Likens. 1979. Patterns and process in a forested ecosystem. Springer-Verlag, N.Y. 253 pp.

Briese, Linda A., and M. H. Smith. 1974. Seasonal abundance and movement of small mammals. J. Mammal. *55*:615-629.

Carpenter, Stanley B., and R. L. Rumsey. 1976. Trees and shrubs of Robinson Forest, Breathitt County, Kentucky. Castanea *41*:277-282.

Dewey, John B. 1980. "Gridball Pellets" — a new tool for brush control in pines. Forest Farmer *39*(20):14-15, 34.

Dueser, Raymond D., and H. H. Shugart, Jr. 1978. Microhabitats in a forest-floor small mammal fauna. Ecology *59*:89-98.

Geier, Anthony R., and L. B. Best. 1980. Habitat selection by small mammals of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. *44*:16-24.

Gentry, John B., E. P. Odum, M. Mason, V. Nabholz, S. Marshall and J. T. McGinnis. 1968. The effect of altitude and forest manipulation on relative abundance of small mammals. J. Mammal. *49*:539-541.

Getz, Lowell L. 1961. Factors influencing the local distribution of shrews. Am. Midl. Nat. *65*:67-88.

Gottschalk, Marlin R., and D. J. Shure. 1979. Herbicide effects on leaf litter decomposition processes in an oak-hickory forest. Ecology *60*:143-151.

Hahn, Brad L., and E. D. Michael. 1980. Responses of small mammals to whole tree harvesting in central Appalachia. Trans. Northeast Fish and Wildl. Conf. *37*:32-44.

Helwig, Jane T., and K. A. Council (eds.). 1979. SAS users guide, 1979 edition. SAS Institute, Raleigh. 494 pp.

James, Francis C., and H. H. Shugart, Jr. 1971. A quantitative method of habitat description. Audubon Field Notes *24*:727-736.

Kirkland, Gordon L., Jr. 1977. Responses of small mammals to the clearcutting of northern Appalachian forests. J. Mammal. *58*:600-609.

________. 1978. Population and community responses of small mammals to 2,4,5,-T. U.S. Dep. Agric. For. Serv. Res. Note PNW-314. 7 pp.

Linzey, Donald W. 1968. An ecological study of the golden mouse, *Ochrotomys nuttalli,* in the Great Smoky Mountains National Park. Am. Midl. Nat. *79*:320-345.

Loftis, David L. 1978. Preharvest herbicide control of undesirable vegetation in southern Appalachian hardwoods. South. J. Appl. For. *2*:51-54.

Manville, Richard H. 1949. A study of small mammal populations in Northern Michigan. Misc. Publ. Mus. Zool. Univ. Mich. *73*:1-83

McCaffery, Keith R., F. L. Johnson and L. D. Martoglio. 1974. Maintaining wildlife openings with pellets containing picloram. Wildl. Soc. Bull. *2*:40-45.

McCollister, D. D., and M. L. Leng. 1969. Toxicology of picloram: safety evaluation of Tordon herbicides. Down-to-Earth *25*(2):5-10.

McComb, William C., and R. L. Rumsey. 1981. Habitat characteristics of forest clearings created by picloram herbicides and clearcutting. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. *35*:(in press).

Murphy, Patrick K., and R. E. Noble. 1972. The monthly availability and use of browse plants by deer on a bottomland hardwood area in Tensas Parish, Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. *26*:39-57.

Pruitt, William O. 1953. An analysis of some physical factors affecting the local distribution of the shorttail shrew (*Blarina brevicauda*) in the northern part of the Lower Peninsula of Michigan. Misc. Publ. Mus. Zool. Univ. Mich. *79*:1-39.

Wetzel, Ralph M. 1958. Mammalian succession on midwestern flood plains. Ecology *39*:262-271.

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